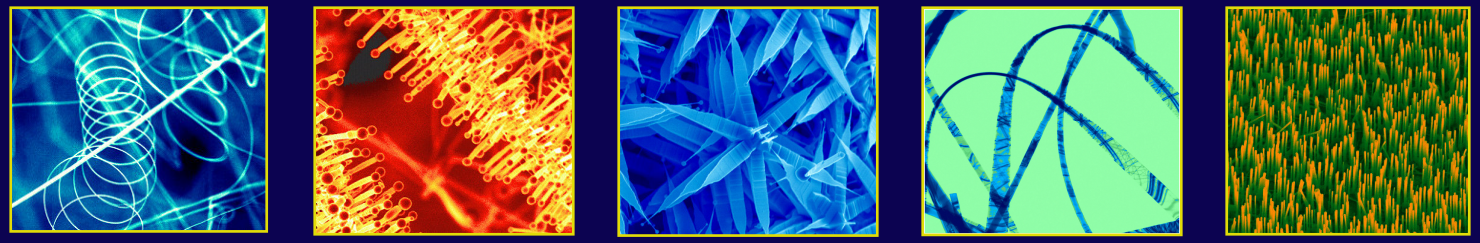


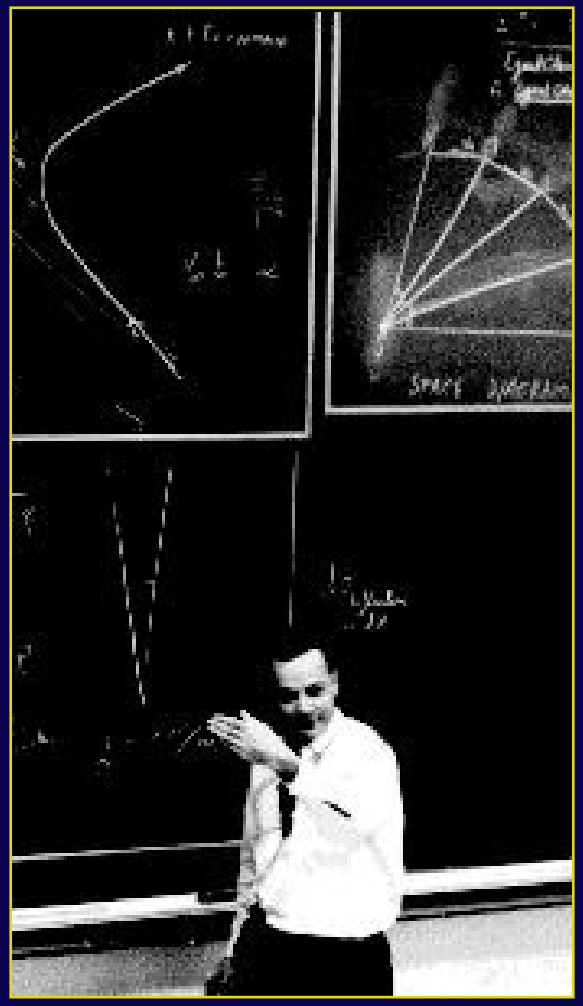
Nanotechnology: Small is big business

Dr. G. Wayne Clough

President, Georgia Institute of Technology

Rotary International Southeast Leadership Institute

September 30, 2005



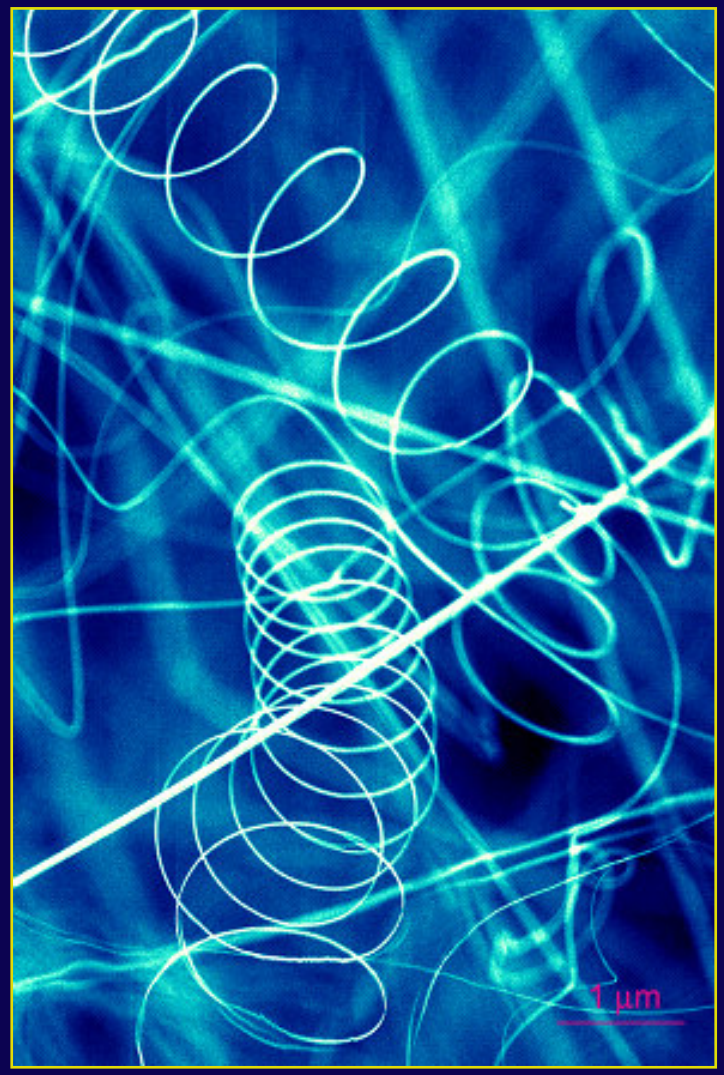
Courtesy of the Archives, California Institute of Technology

"I would like to describe a field in which little has been done, but in which an enormous amount can be done… In the year 2000, when they look back at this age, they will wonder why it was not until the year 1960 that anybody began seriously to move in this direction."

"There's Plenty of Room at the Bottom," Richard Feynman's December 29, 1959 address to the American Physical Society introducing nanotechnology.

Nano is small

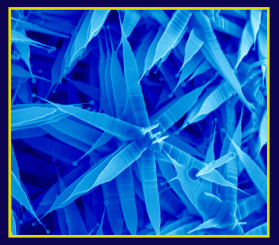
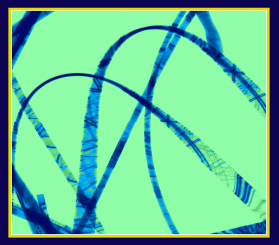
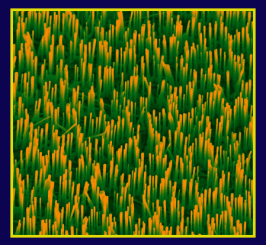
Nanoscience and nano-technology are a revolution in the way we deal with matter. Scientists and engineers study the characteristics and behavior of atoms and molecules, then use that knowledge to create new materials and develop tiny nano-scale machines.



Nanosprings of zinc oxide synthesized at Georgia Tech

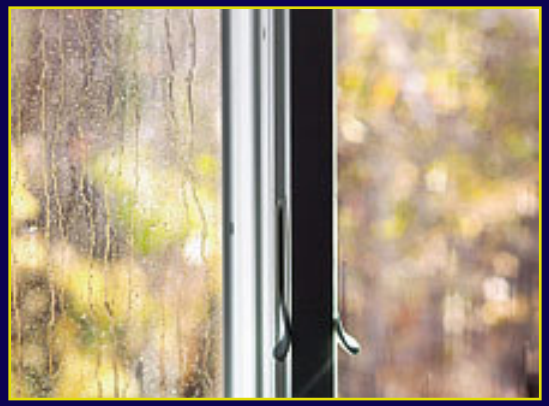
A nanometer is one-billionth of a meter.

Small is big

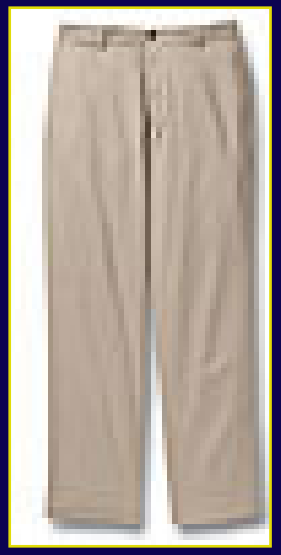




- Coming nanotechnology revolution will touch virtually every aspect of our lives.
- Products incorporating nanotechnology generated sales of $26.5 billion in 2001; predicted to exceed $2.6 trillion within 10 years.
- Federal research investment: $4 billion
- Major companies like IBM and Intel have nano initiatives; more than 400 new, purely nano companies have already been created.

Early nano-products on the market



- Nano-film on windows releases dirt so rain can wash it away.
- Fibers with nano-coatings that shed dirt and wrinkles.



- Nano-engineered materials that are lightweight but strong for running boards in vans.

"Everything being made of atoms, the capability to measure, manipulate, simulate, and visualize at the atomic scale potentially touches every material aspect of our interaction with the world around us."

John Marburger III
Science Advisor to the President

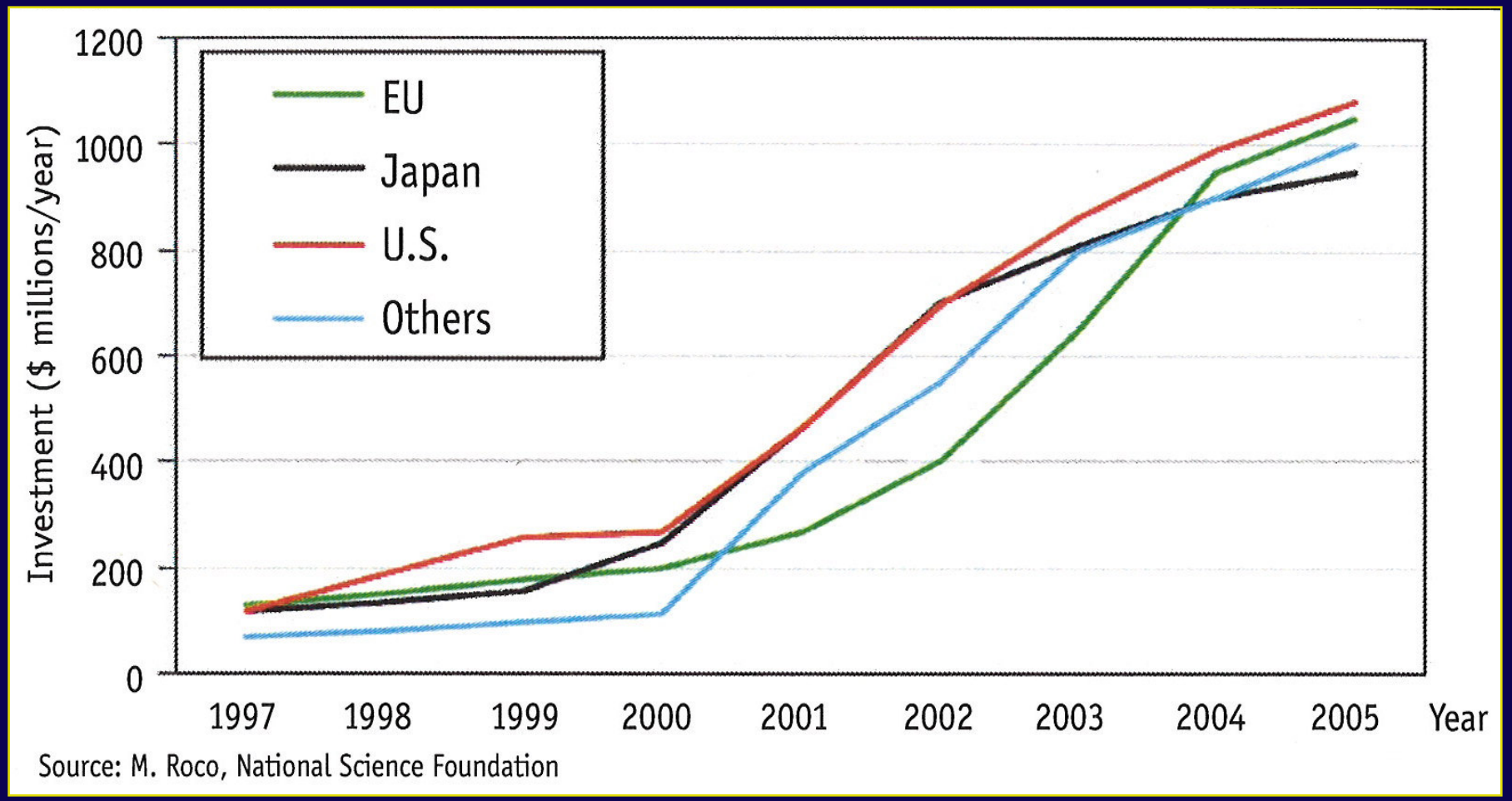
"Nanotechnology has a mortal lock on being tomorrow's gold mine. It will produce trillions of dollars in new wealth over the next century. It is sure to reshape every industry it touches."

Rick Karlgaard, publisher
Forbes

"Nanotechnology is a driving force in the development of energy sources and technology for the future."

John Rice, president & CEO
GE Energy

Government nanotechnology R&D investments in 1997-2004



National Nanotechnology Initiative

- Coordinates the nation's multi-faceted nano-technology research investment.
- Develops educational resources, supporting infrastructure.
- Facilitates technology transfer, economic benefits.
- Addresses issues of safety, security, ethics.
  - National Science Foundation Center on Nanotechnology and Policy

National Nanotechnology Infrastructure Network

- Cornell
- Stanford
- UC Santa Barbara
- Howard University
- U Michigan
- Penn State
- U Minnesota
- U New Mexico
- U Washington
- **Georgia Tech**
- Harvard University
- U Texas - Austin

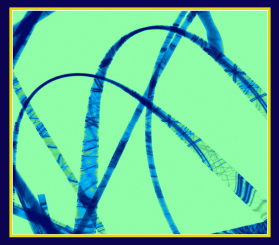
Georgia Tech: Recognized for excellence

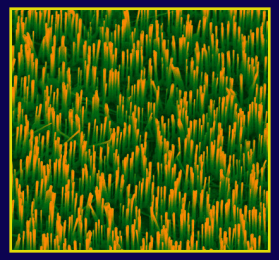
- Among top 10 public universities in the nation.
- Among top 5 engineering schools in the nation.
- Nationally ranked: computing, architecture, management, selected science and liberal arts programs.
- SAT score among nation's top 5 public universities.
- 15 national centers of excellence.

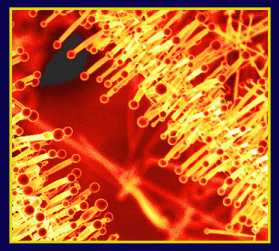
GT: A leader in nanotechnology

- Faculty includes:
  - 2 winners of the Feynman Prize
  - One of the world's most-cited nano-engineers
- GT one of 13 universities in the NNIN.
- GT/Emory leads in grants for nano-medicine research.
- Wayne Clough serves on PCAST, NSB, and the Federal Oversight Board for NNI.

Focal points for nanotechnology research at Georgia Tech

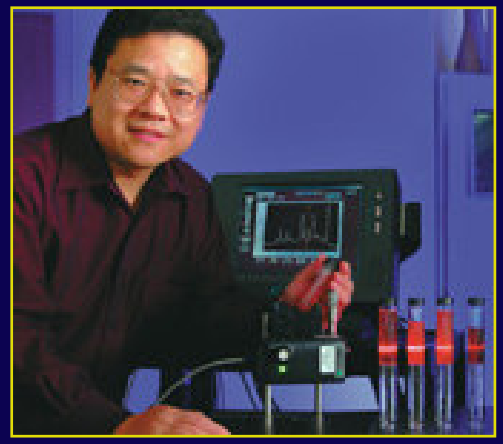






- Nanomedicine, nano-biotechnology with Emory University
- Nanomaterials/energy
- Nanoscale manufacturing
- Photonics
- Education

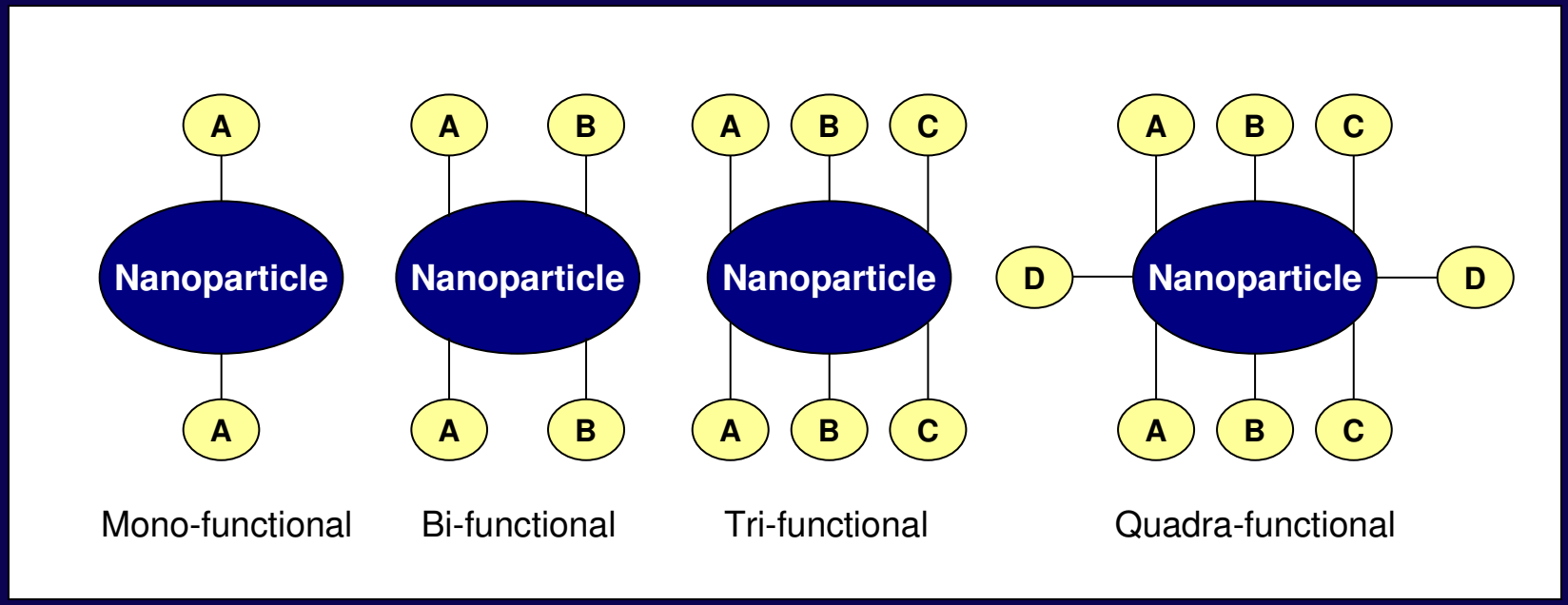
Pioneering nanomedicine



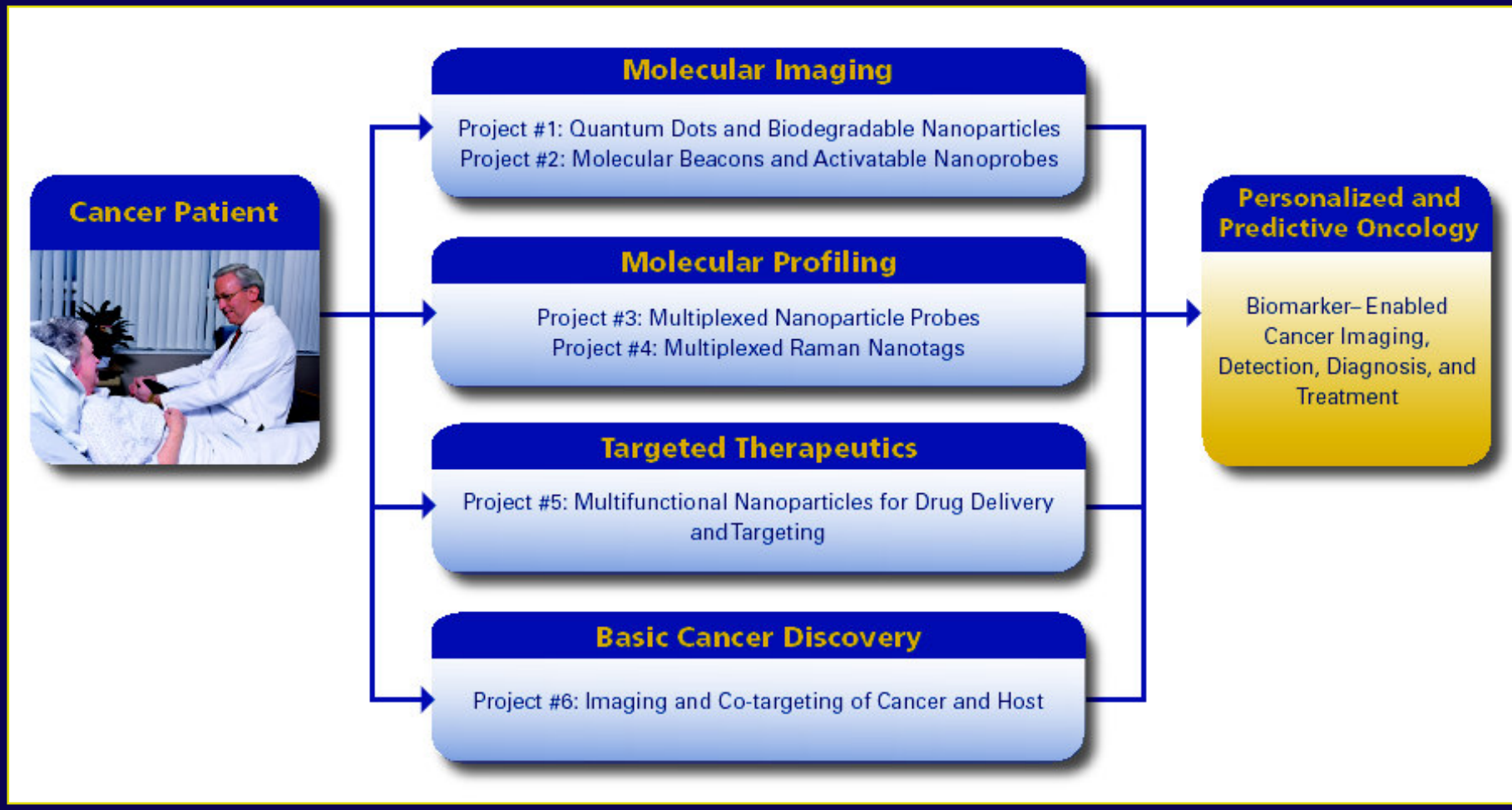
Biomedical Engineering Professors Shuming Nie and Gang Bao are pioneers in applying nanoscience and nano-technology to medicine.

Their work was critical in helping Georgia Tech and Emory attract a $19 million National Center of Cancer Nanotechnology Excellence.

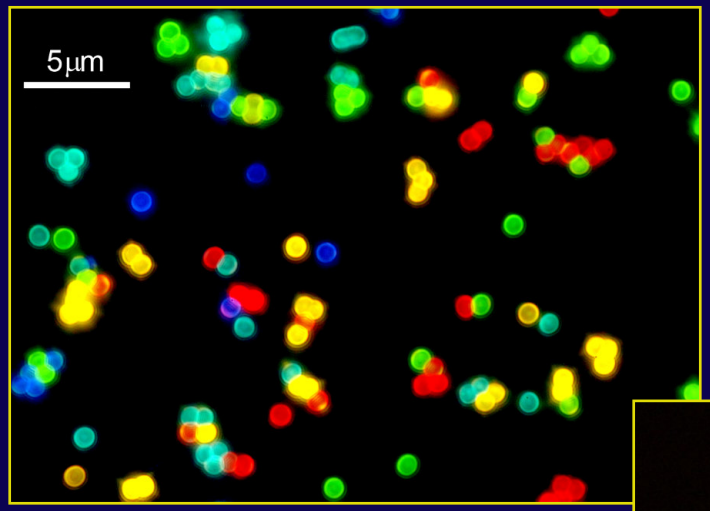
Nanomedicine: Creating multifunctional nanoparticle agents



Nanomedicine's potential: Personalized and predictive oncology



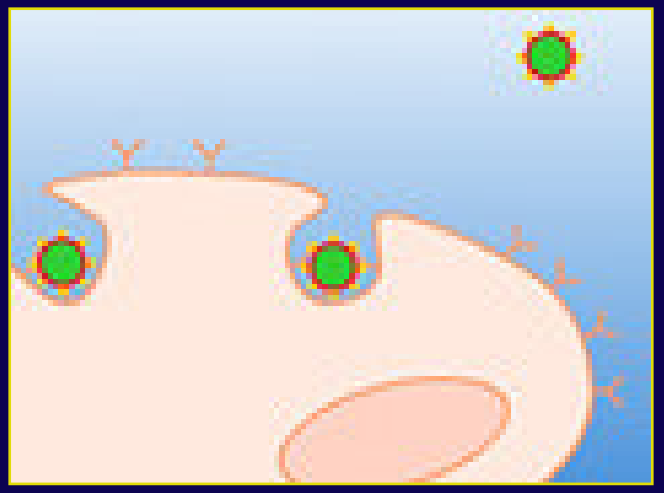
Molecular imaging



Nanoparticles called quantum dots have fluorescent beacons and are engineered to bond to particular cells.

When the quantum dots find target cells and bond to them, the beacons light up.

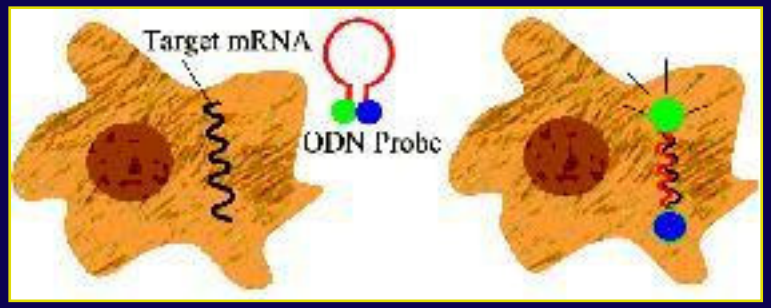
Targeted therapeutics



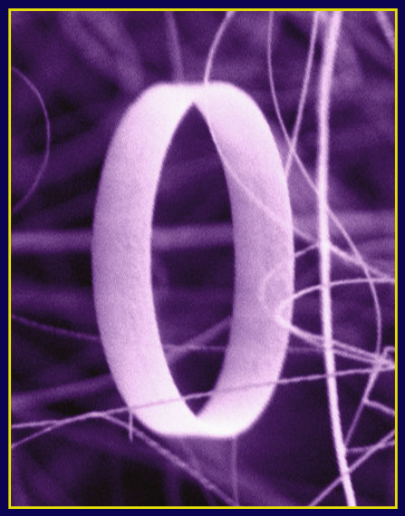
Nanoparticles with a pharmaceutical payload trick cancer cells into absorbing them. Once inside, the particles release their payload, killing the cells without the collateral damage of traditional chemotherapy.

Basic molecular discovery

Nanoparticles are engineered to seek out particular genes and illuminate them with fluorescent dye, a potential tool for detecting disease-related genetic markers.

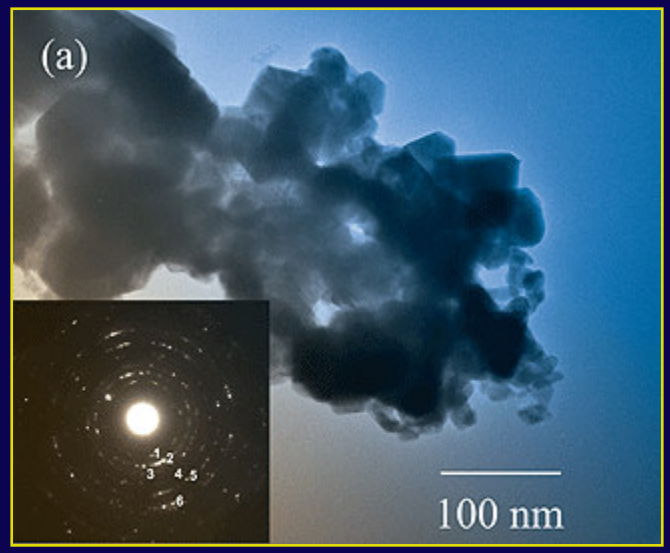


Nanomaterials/energy



Nanoscale rings, tubes, belts, wires, and springs are potential building blocks for tiny microsensors for ongoing monitoring of biomedical measures like blood pressure, blood flow, and stress at the cellular level.

A nanoporous electrode developed at Georgia Tech has potential to boost the performance of fuel cells, batteries and sensors.



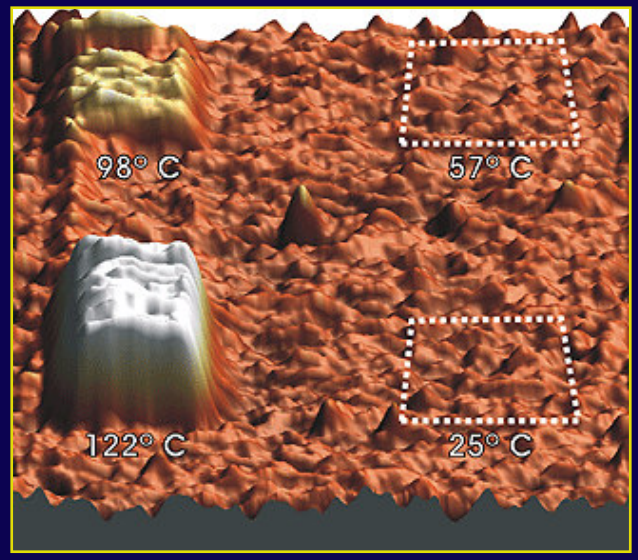
CardioMEMS

- Georgia Tech Professor Mark Allen is a recognized authority on micro-electro-mechanical systems (MEMS), which are electro-mechanical structures at the micron level (1,000 nanometers).
- Working with a cardiologist, he developed a micro-sensor to monitor human blood pressure.
- The sensor is built into a stent or sent through the blood stream to lodge in the patient's lung.
- It sends readings by radiowaves, eliminating the need for costly and damaging CT scans.

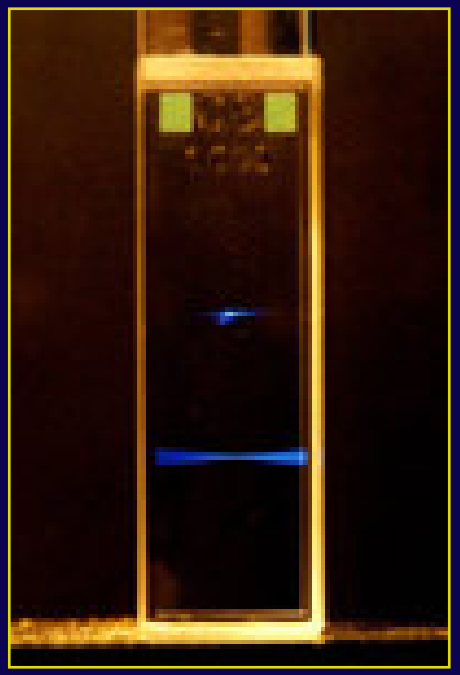
Nanoscale manufacturing

Tech's Microsystems Packaging Research Center, which is the world's largest center dedicated to microsystem packaging technologies, is working on nano-wafer level packaging.

Thermal dip pen nanolithography, developed at Georgia Tech, "writes" nanoscale patterns on a variety of surfaces. It has great potential for nanomanufacturing, especially of semiconductors.



Photonics



Experts in photonics are manipulating the photons in light much as electrons are manipulated in electricity. The resulting new molecules and micro-systems have potential for uses that range from solar cells to micro-electro-mechanical systems, from tissue engineering to display technology.

Students embrace nano

Georgia Tech students in any field can take a 12-credit-hour specialization in nanoscience and technology.

Tech has also established a graduate research fellowship in nanotechnology that provides about $15,000 a year to its fellows.

Nanoscale research requires cleanrooms

- Vibration free
- Particle-free air
- No chemical or bio-contamination
- Precisely controlled temperature and humidity
- Pure gases and water
- Clean, stable electricity

Classes of cleanrooms

- Air is normally filled with microscopic particles
  - Humans give off 600,000 particles per minute from skin and hair.
  - Fabrics, furniture, carpets, walls, ceilings give off hundreds of thousands more.
- Clean room classes
  - Class 1,000 = 1,000 particles per cubic foot of air
  - Class 100 = 100 particles per cubic foot of air
  - Class 10 = 10 particles per cubic foot of air

Georgia Tech's
Nanotechnology Research Center Building

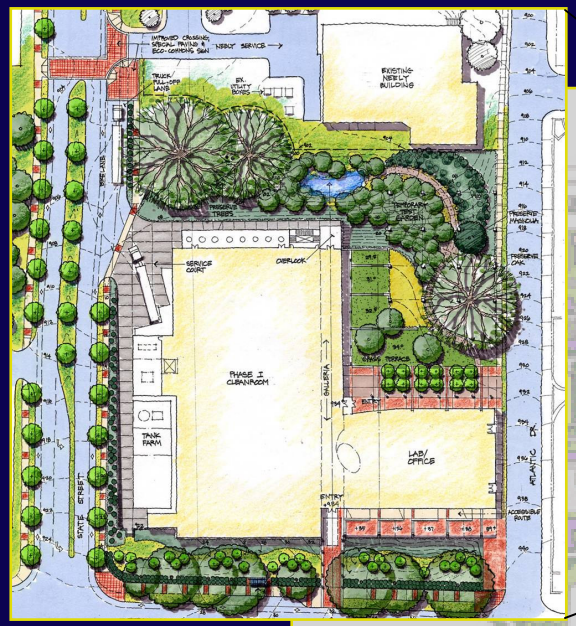
- 188,000 gross sq ft
- 30,000 sq ft of cleanroom labs
- $80 million construction cost

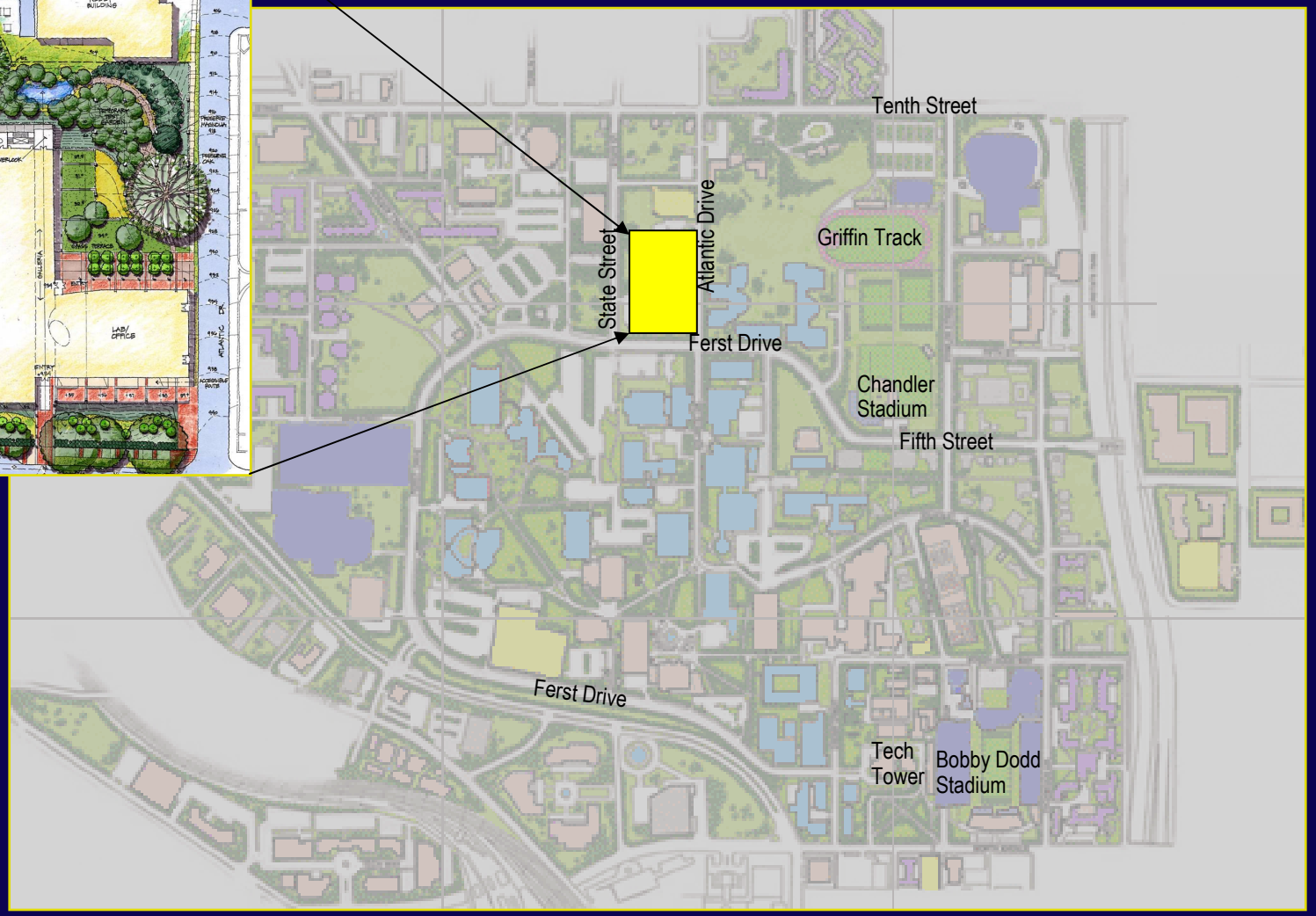
The Nanotechnology Research Center Building will allow Georgia Tech to become pre-eminent in the Southeast and among the leaders in the nation.

Unique advantages of GT's NRCB

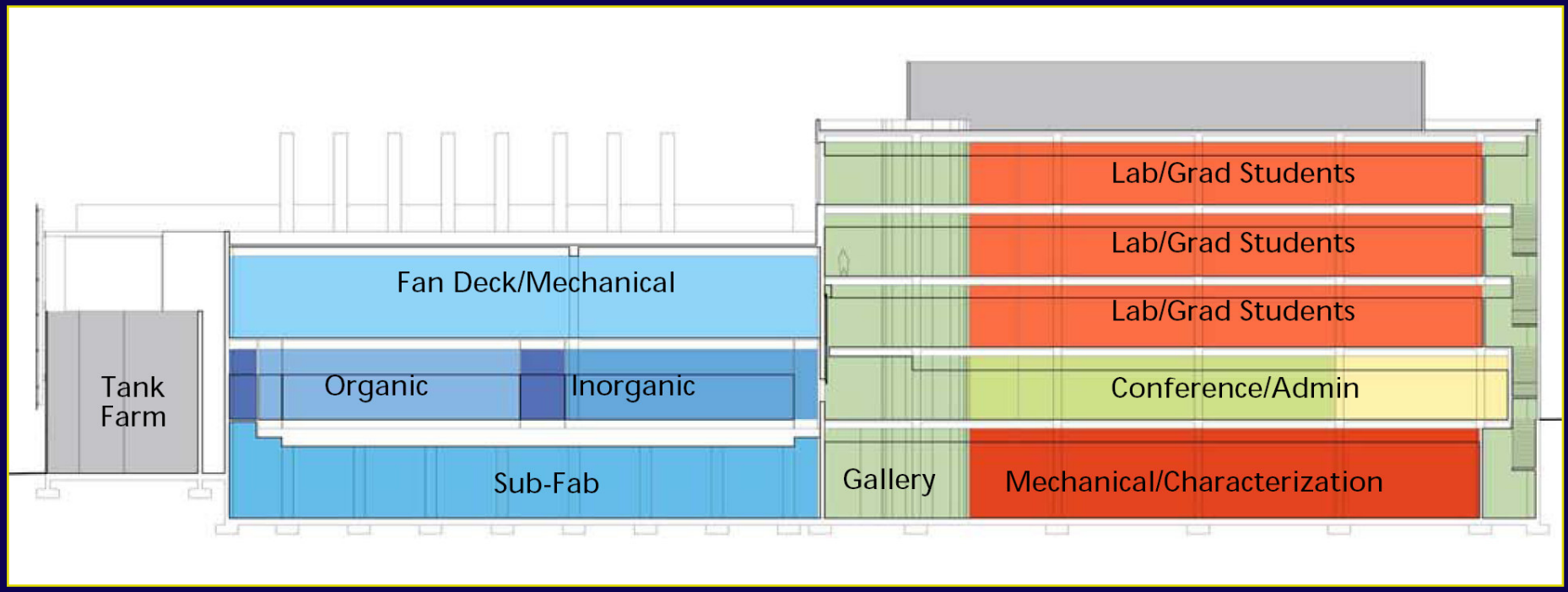
- Large size
- Three "cleanest" classes of labs (10, 100, 1,000)
- Flexible design: lab environment can be reconfigured to serve differing research needs.
- Can handle both inorganic and organic.
- Nano-bio focus
- Interdisciplinary
- Access for users from the Southeast.

NRC Building Location

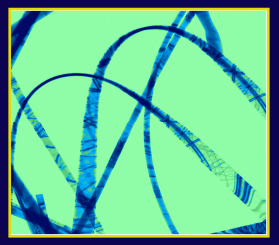


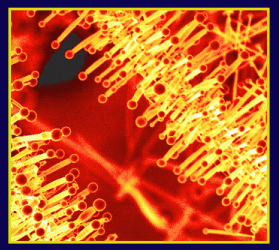


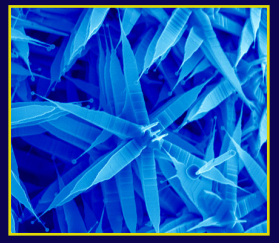
Building cross-section

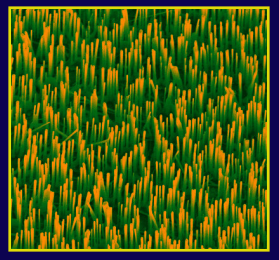


Mechanical controls in space above and below cleanroom allow flexible use.









Conclusion

- The potential of nanotechnology is revolutionary. It will touch virtually every aspect of our lives.
- Nanotechnology research and technology transfer is a federal priority.
- Georgia Tech is a major center of research in nanoscience and nanotechnology.
- The Georgia Tech Nanotechnology Research Center Building will provide a unique regional resource for the Southeast.